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THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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PLATE I

THE APPROACHING SHADOW OF THE MOON, ECLIPSE OF AUGUST 31, 1932

I was a member of the observing party of the Royal Astronomical Society of Canada, stationed on the Fair Grounds at Louiseville on August 31st, 1932, and was fortunate in securing several photographs of cloud formations. Amongst them was the accompanying plate, taken a moment before totality, across the path of the approaching shadow, with centre of plate facing north-west.

The picture was taken with a panoramic camera, with a lens of 6-inch focus, slit shutter and blue screen. The total exposure was under half a second, but as the lens swung through an arc of 120° with slit shutter, from north to south in same direction as advancing shadow, the exposure for any one point on the plate was very rapid. The sun was out of the field about directly over tree in background.

About 2½ minutes before totality the broken clouds that intermittently obscured the sun, moved towards the south and these here shown appeared to be pushed slowly back towards the north and east as the shadow rushed across them, leaving a clear passage for totality, with a blue sky above and the air perfectly still about us.—J. WHITEHOUSE.

Journal of the Royal Astronomical Society of Canada, 1933.

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OF CANADA

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RADIO TALKS OVER CFCF (VICTORIA, B.C.)

By W. E. HARPER

LVII—THE 1932 MEETING OF THE ROYAL SOCIETY OF CANADA

(June 21, 1932)

DURING the closing days of the past month there was held in the city of Ottawa the fiftieth anniversary meeting of the Royal Society of Canada. It is felt that some notes of a general character concerning the Society and of the addresses delivered on that occasion might be of interest to several of my radio audience.

The Society is the premier organization in our country banding together the workers in the arts and sciences. It was largely on the initiative of the then Governor-General, the Marquis of Lorne, that the Society was formed in 1882. He realized the value of the scattered workers coming together for consultation and discussion of the research problems in which they were engaged.

The constitution as drawn up and adopted provides for five main sections: I—French Literature and History; II—English Literature and History; III—Physical Science; IV—Geology and Mineralogy and V—Biological Science. Fellowship in the Society is elective and is confined to Canada. Originally a quota was set for each section and elections were possible only when vacancies occurred through death or resignations. So marked an increase in

the number of workers in science has taken place in recent years, however, that it was felt many of the younger men, well qualified to be admitted as Fellows, were debarred by the quota regulation. Thus a change has been made in the scientific sections whereby three are elected annually irrespective of whether vacancies have occurred or not. The quota for our own section III, which embraces mathematics, physics, chemistry and astronomy, was originally 50; now there are 64 Fellows in this section.

The groups met separately for the reading and discussion of papers. Indeed so highly specialized were some of the papers within section III itself that subsections were formed, the mathematicians forming one group, the physicists another and the chemists another. The astronomers of course are supposed to know a little about all three and could take their choice of what seemed of most interest to them. In general though the section met as a unit to hear the 114 papers which were presented. It would be out of place though on a warm summer evening to inflict highly technical papers upon a radio audience, so items of a popular nature only will be given.

The meetings were held in the new Research Laboratory on Sussex Street. The building is 418 feet long, 176 feet deep and 60 feet high with two interior courts so that all rooms are well lighted. The contract for this splendid building was let in 1930 and it was planned to have the formal opening and dedication as part of the programme at this semi-centennial gathering. This part of the ceremony had to be omitted, for while the building itself is complete little or none of the equipment is yet at hand.

This building will house the National Research Council and its staff, now numbering over a hundred, who are charged with the solution of technical problems given them by the Government and also with initiating and carrying out such researches as will utilize the natural resources of the country and eliminate waste. The creation of such a research organization was sponsored by the Royal Society and a brief recital of some of the investigations now in progress may help to show the varied character of such research.

In agriculture we have many experiments going on to obtain the best varieties of seed grain, especially wheat that will mature early and be free from rust. The new Garnet variety while maturing

earlier than the Marquis is more susceptible to rust. The problem of weed control, particularly the dandelion, couch grass and sow-thistle is engaging the attention of one investigator. Then we have animal diseases and of these the one that comes closest home to our own province of British Columbia is that of fowl paralysis, which has made such inroads upon our poultry flocks the past few years.

The great northland of Canada is rapidly opening up through the use of the aeroplane, which makes use of the numerous small lakes as landing places. To test out aircraft design a huge wind tunnel of circular cross-section, nine feet in diameter, has been constructed through which air can be forced at any desired speed. A model built to scale and fixed in the tunnel can be studied for the stresses and strains in its various parts, under conditions encountered in actual flying, without the element of danger to human life. Moreover, as the flying boat is so much used in northern Canada provision is made for additional studies upon that particular type by means of a water tank 400 feet long, 9 feet wide and 6 feet deep through which waterway model boats can be dragged at speeds comparable to those met with in actual flying. The best design naturally will come about from a study of the forces found necessary as registered by delicate instruments.

Increasing use of the radio and the limited number of wave-lengths available makes it necessary that each station hold closely to its allotted wave-length if congestion of the air is to be avoided. Studies are under way to improve the precision in broadcasting so that stations can narrow down the width of band now found necessary. Standards will be adopted so that all stations will be forced to conform rigidly to their aliotted wave-length. Such is necessary in international negotiations. Another problem engaging attention in radio is the variation in the height of the Heaviside layer and its connection with the "fading" so often noticed in wireless reception. At another time I may go into this subject more fully.

The damage done by the smelter smoke at Trail, B.C., to foliage and crops south of the border has created an international problem. Happily the damage claims are being adjusted by an International Commission, but to solve the problem for all time, research is being

conducted to transform the injurious sulphur dioxide gases into fertilizers and aid to this end has been given by our National Research Council.

These few selected items from the many investigations in progress show how closely such scientific efforts are related to the industrial life of our day.

In his presidential address Sir Robert Falconer gave a general survey of the advances in the intellectual life of Canada during the past fifty years. Supplementing this were the addresses of the chairmen of the various sections which were more specific and dealt with the progress in their own particular fields. These addresses supplemented again by articles from other recognized leaders in the arts and sciences were printed and bound in a souvenir volume entitled "Fifty Years Retrospect", the reading of which gives a good idea of Canadian achievement during that epoch.

Many luncheons featured the meetings at which eminent men were heard. The second day's luncheon in the Chateau Laurier had as the theme for the addresses—"The Learned Societies of Great Britain, the United States and France". In proposing the toast to the first one Premier Bennett used this expression—"Deeds of those working in the arts and sciences cannot be measured by the slide-rule of monetary values". Dr. Seward of Cambridge, England, in responding said, that many people were deterred from learning natural science because technical terms were employed and if he were a dictator he would force everyone presenting a paper to add a short summary comprehensible to the layman. (Your speaker has been trying to do this very thing for several years.)

Mackenzie King paid tribute to the wealthy men of the United States, who were among the first to recognize the importance of science and who had contributed so much to research. Dr. Bancroft of Cornell, replying, showed how important it was to cultivate the border lines of science and how admirably the Royal Society was fitted to do this very thing.

LVIII—THE RADIO ECLIPSE OF AUGUST 31, 1932

(July 19, 1932)

Nearly every one knows now of the total solar eclipse which is to occur on August 31st next and which will be visible in eastern

Canada. The path of totality crosses Hudson Bay from north-west to south-east, continues through Quebec, crossing the St. Lawrence a little east of Montreal and enters the Atlantic Ocean near Portland, Maine. The width of the path is about 100 miles and the duration at the central line averages about 100 seconds. The chances are about fifty-fifty for clear sky at the time of the eclipse and elaborate preparations are being made by astronomers of many countries to observe it. A large party of British astronomers are touring Canada just preceding the eclipse and will spend four days in Victoria.

The eclipse I wish to speak of tonight is of quite a different kind to the optical one in which the astronomers are so vitally interested. Indeed its reality has yet to be tested for it is only in recent months that the possibility of there being such a phenomenon has been recognized. To put it in brief right at the start it is thought that the moon which occults the light of the sun also cuts off certain charged particles shot off from the sun and that the cessation of the bombardment of these particles or corpuscles will have marked effects on radio reception.

It is well though to speak of the investigations which have led up to this conclusion and while investigations on wireless have been carried out in all countries those in England during the past seven years have contributed most to the question at issue and these alone will be outlined.

Wireless waves travel with the speed of light but are of much greater wave-length. The average wave-length of visible light is about 1/50,000 inch; the radio waves that carry my voice out to you are 379 metres or nearly one-quarter of a mile long. You may think of wireless waves as analogous to water waves or waves set up in a rope secured at one end and the other vibrated up and down. The distance from crest to crest is known as the wave-length and may be a few inches or a few miles in length but their speed of propagation is in every case that of light, namely 186,000 miles per second.

A complete theory of wireless transmission must explain (1) why long distance communication is possible and (2) why large and rapid variation in intensity and direction of the waves is possible. Both phenomena are explainable on the theory that there exists high up

in the atmosphere a layer which serves to reflect the waves back to earth. This layer is termed the Kennelly-Heaviside layer, after its discoverers, or sometimes simply the Heaviside layer. By sending out signals from a central station and picking them up at stated distances from that station the English physicists under Appleton were able to show that the variation in intensity of the signals—the *fading* so well known to us all—was due to the interference of two or more rays arriving at the receiver with a definite path difference. One of these rays had come the direct course along the surface of the earth, the other had gone upwards and been reflected from the Heaviside layer reaching the receiver just a little out of step with the ground wave. Being out of step, interference would result with consequent fading. By studying the amount of the fading with the location of the stations it was possible to arrive at the height of the layer and 100 km or 63 miles was the value arrived at.

The nature of this layer which serves to reflect the wireless ray back to earth is somewhat too technical to enter into. At its height of approximately 63 miles the density of the atmosphere must be exceedingly low, a condition favourable to what we call ionization or the breaking up of the atoms. The ionization of this layer is greatest at midday, decreases rapidly after sunset and increases the moment the first rays of the sun strike it again in the morning. Hence the ionizing agent is thought to be the sun either through its ultra-violet light or material particles shot out from its surface.

A new development came when they found that by increasing the frequency, *i.e.*, by decreasing the wave-length, they could penetrate this layer and have the waves returned from a layer at the height of about 145 miles. During the daytime for ordinary frequencies used in broadcasting the ground rays are the main ones for stations within 100 miles. Beyond that distance the atmospheric rays play a more important rôle than the ground rays. Critical changes occur at sunset and sunrise in the ionized state of the atmosphere. A little after sunset when the sun's rays have left the upper atmosphere and their influence ceases there the broken up atoms recombine and the layer loses its ability to return the wireless waves. In other words the height of a layer that will return them increases rapidly just after sunset and keeps on increas-

ing a little through the night until just before dawn when the measured height is in the neighbourhood of 145 miles. About 30 or 40 minutes before sunrise occurs on the ground level and about the time the sun's rays again light up the upper air the ionizing layer is found to decrease in height rapidly until the daytime level is again reached.

These observations have suggested that there may be in effect two reflecting layers brought into operation in two different ways. It would seem beyond question that the sun is the agent in both cases, its ultra-violet light being the cause of ionization of one layer and possibly solid corpuscles shot off from its surface the cause of the other.

Opinion is divided, but a unique opportunity is afforded at the August eclipse to test out rival theories. If solid corpuscles are the working agents a marked difference in time and position of the radio phenomenon should be shown with respect to the optical eclipse in which the astronomer is so interested. This comes about from the fact that light travels about 186 times faster than the solid corpuscles expelled from the sun's surface. Whereas the optical eclipse lasts only 100 seconds, the radio manifestation should persist for 74 minutes and cover a wide extent of country, the central path skirting the Labrador coast. Moreover though the astronomer has to take his chance on a clear sky this radio phenomenon will be observable whether the skies be clear or cloudy.

There is at present in the Labrador region a Canadian scientific expedition stationed at Hamilton Inlet for a whole year's programme of meteorological and magnetic observations. It is likely they will be sent the necessary equipment to observe whether the theory so recently advanced is borne out by the predicted manifestations actually occurring.

The whole question, while one of pure science, has great practical applications in wireless.

LIX—COSMIC RAYS

(October 18, 1932)

The question has often been asked as to how long our Sun will endure since it is radiating away its heat continuously. The amount we receive on the earth is only an infinitesimal part of its

total output for it is puring out its heat, not only towards our own small planet but in all other directions as well. This loss of heat must be at the expense of its mass whose total must be diminishing as the milleniums roll by. And since the stars are known to be suns, quite similar to our own, and radiating likewise their masses away, the larger question is forced upon one—Is the whole universe running down? What will happen when all the stars will have radiated away all of their mass? Will it be the cold, dead emptiness of space alone that is left? For those who concern themselves only with the present such questions have no appeal, for we know that although the sun is losing mass at four million tons a second, it nevertheless has sources of heat sufficient to last for millions of years to come. But for the philosophers who sought an answer to such questions there seemed from the work of the astronomers to be only one answer and that was that the universe was indeed gradually running down.

Of recent years there has been some evidence to suggest that possibly the reverse process may also be in operation, namely, that matter may be reformed out of the radiated energy which has been scattered so prodigally throughout space. In particular, Millikan, one of the world's outstanding physicists, who is head of the Norman Bridge Laboratory at Pasadena, believes that the Cosmic Rays of which we hear so much in the papers of late represent the birth pangs of the atoms of helium, oxygen and silicon which are formed out of the electrons and protons in interstellar space.

The rays with which we are most familiar are those of light. White light is composite consisting of all the rainbow colours, red, orange.....violet; the wave-length diminishing as we proceed from the red to the violet. The wave-length of red light is about 1/35,000 of an inch, that of the violet about 1/70,000 of an inch. Farther to the redward end of the spectrum are radiations of greater wave-lengths and likewise farther to the violet end, in what we speak of as the ultra-violet, are radiations of increasingly shorter wave-length whose presence is known by their photographic and other effects. Going still farther down the scale we have the X-rays, so useful in medical practice, whose wave-length is about 1/1,000 that of visible light, whilst the cosmic rays we are discussing are 10,000 times as short again as X-rays.

The discovery of these peculiar radiations was made at Toronto about 30 years ago when I was a student at the University there. Professor McLennan, recently retired from the chair of Physics, and his assistant Burton, who now succeeds him, were studying the rate of leakage of an electric charge from an electroscope. Many of my listeners will understand the principle of the gold-leaf electroscope they were using, wherein a charge is given to the leaves which are repelled from each other and only fall together again when the charge on them has been dissipated away into space. These investigators found that by surrounding the electroscope by an air-tight metal chamber the rate of discharge could be reduced 30 per cent. This meant that the loss of charge must be due in part at least to some highly penetrating rays, like the gamma rays of radium, which could pass through metal walls and ionize the gas inside. This so-called penetrating radiation was at first quite naturally ascribed to radioactive materials in the earth and air, and this is in fact the origin of the greater part of it.

It would be expected, then, that the farther one got away from the earth, the less would be its effect on the discharge rate. Professor Eve of McGill calculated such effect should be cut in two, at an altitude of only 250 feet. But in 1910 a Swiss physicist, Gockel, took an electroscope up in a balloon to a height of nearly three miles and found the penetrating radiation at this altitude almost as great as at the earth's surface. This was verified later by several others.

The war put a stop to experiments and it was not until 1921 that Millikan and his associates at Pasadena and Kolhörster in Germany again studied its characteristics on high mountain peaks and through balloon ascents. Millikan succeeded in sending automatic recording apparatus as high as ten miles in 1922 and from this and similar work in subsequent years he was able to gather valuable information as to the character of these rays which were now looked upon as coming from outside the earth. Moreover, by sinking the apparatus to various depths in snow-fed lakes at great altitudes, he was led to the conclusion that not only was there this radiation from outside space, and hence called "cosmic radiation" but that it was indeed highly penetrating, the most vigorous of the three

separate varieties found being sufficient to penetrate 200 feet of water or 18 feet of lead before becoming completely absorbed.

The origin of these cosmic rays is still a matter of debate. They do not come direct from the sun else their effect should be greater at noonday than at midnight. At one time it was thought that they were stronger when the Milky Way regions were overhead; this was shown later to be based on insufficient evidence and now it is accepted that they come equally strong from all directions in space.

What is there out in empty space that could give rise to these? Millikan believes that they do not come from the distant stars or nebulae but that they represent energy radiated during the actual creation of the most common atoms of which our universe is composed. Matter consists, as most people are now aware, of positive and negative charges of electricity. The lightest atom of all, hydrogen, has its positive nucleus and one negative charge or electron surrounding it; helium has two, lithium three and so on until we reach the heaviest, uranium, with 92 electrons. In the fierce turmoil in the interior of our sun or other stars these atoms are broken up and escape as radiant energy. It is this same radiant energy in the form of tiny positive and negative charges which Millikan believes come together again where conditions of exceedingly low temperature and pressure in outer space are favourable to their recombination. There, due to chance encounters of the right number of positive and negative charges the more common atoms of helium, oxygen and silicon are reborn. It is an exciting theory of creation still going on and his recent experiments have the object of securing new and corroborating data from the upper atmosphere.

A few months ago cosmic rays were produced artificially in the laboratory of the University of Giessen through the bombardment of atoms of beryllium by the so-called *alpha* particles. The suggestion comes also from Chadwick of the University of Cambridge, England, that these rays may be a flood of neutrons, a neutron being a combination of the proton and electron without electrical charge.

LX—MIRAGES

(November 15, 1932)

In the hot desert travellers sometimes imagine they see pools of water and palm trees, often upside down, which vanish from view on near approach. Such an illusion is known as a "mirage". Those of us living on the straits often see similar illusions in that the opposite shores are apparently raised unduly above the water's edge and appear as chalky cliffs a few hundred feet in height. Occasionally too, a ship will appear to be lifted clear out of the water and may sometimes indeed be seen inverted. Such phenomena are, as just stated, known as mirages and they owe their explanation to a very simple property of light.

If we project a ray of light obliquely on to water in a glass vessel we will notice that its direction will be changed at the point where it strikes the water. The ray will be bent towards the perpendicular to the surface of the water, although its path through the water will be a straight line as it is through the air. This bending is termed "refraction", and light is in general refracted when it passes from one medium to another of different density. The greater the difference of density the greater will be the refraction.

As a simple illustration we may take the case of a rod plunged obliquely into a vessel containing water. It will seem to be broken at the surface, the part under water being bent with respect to the part out of the water. As an illustration of an astronomical nature, we may cite the difference between the real and apparent positions of a star seen, say, half way down from the zenith to the horizon. If the star was vertically above us there would be no difference between the real and the apparent position. But when half way down in the sky the rays of light are coming to us obliquely and entering, successively, denser layers of our atmosphere. The same effect occurs as with the stick in the water only there is not a sharp discontinuity in the direction but a gradual one. The path of the rays is a curved one and the star appears to be slightly higher up in the sky than it actually is. The maximum effect will occur at the horizon where the air is densest and at sunset our luminary is, in effect, lifted in the sky and sets nearly four minutes later than if there were no atmosphere at all. A similar thing happens at

sunrise. The rays by which we see the sun below the horizon are curved like the spherical surface of the earth, only more so. The short portion of the path, though, near the observer's eye when produced backward appears to strike the horizon line. Thus refraction of our atmosphere enables us to see the sun while it is still actually below our horizon line.

Now let us consider the case of the cliffs on the opposite shore. Often from Victoria we see those between Port Angeles and Seattle lifted apparently a hundred feet, or more, higher than they actually are. Why is this? In general you understand that the atmosphere whether over land or water is densest nearest the surface and gradually becomes more and more rarefied the higher up one goes. Warm air, moreover, is less dense than cool air and since large bodies of water have a moderating influence, it may come about that the layer near the surface of the water will have a density less than layers immediately above. Many causes can produce such an abnormal stratification; for example, a breeze from the snow-capped Olympics blowing across the straits could chill the air fifty feet or so above the surface of the water, whilst that at the surface remains for a while fairly warm and consequently rarefied. Thus, the density would increase from the surface of the water to a maximum possibly fifty feet above the water after which it would diminish in the usual manner. Such a layer, densest at the middle and diminishing in each direction vertically, would act as a lens and the opposite shore line when viewed from our own elevated shores would be magnified in a vertical direction.

The same effect will be produced on a ship passing down the straits; it will be apparently stretched in a vertical direction. Such phenomena happen only when there is a very gradual change of density; if the change is very abrupt quite a different phenomenon may be observed. It may even happen that the density gradient in the upper half of the atmospheric lens will be such as to produce an image of the ship above the ship itself and inverted. The ship will appear to be in the clouds and sailing upside down. Indeed the more abnormal the stratification of the air is, the more weird and fantastic shapes will be assumed by the ship or other objects.

One of our summer assistants in July, 1927, noticed an unusual formation when looking from the cliffs along Dallas Road at a ship

some six miles out. The ship was seen direct as on a clear day and in addition there were seen above it two complete images, the lower one of which was inverted. The images were clear cut and joined with keel to keel, while some little space separated them from the ship itself. Similar instances have been noted off the east coast of England. Ships with hulls painted black and lowest parts red appear like two, one inverted over the other, there being the broad, black strip between two bands of red in the mirage effect.

In the case of mirages over desert wastes, we have often read of travellers who, parched with thirst, have fancied they saw bodies of water just ahead. Here the cause is somewhat similar to that over bodies of water. The hottest layers are naturally nearest the burning desert sands, the cooler and denser layers being increasingly farther removed from the surface. The light from a fleecy cloud in the sky starts downward and coming into lighter air becomes bent flatter and flatter, finding its way horizontal along the earth's surface till it enters the eye of the weary traveller. It appears to him to come from straight ahead and seems like a pool of water. He urges himself forward to slake his thirst only to find it vanish on his approach.

Coming nearer home, we have all noticed similar effects on a hot summer day when driving along a paved street. When going up a slight rise, as our eye becomes level with the street ahead, have we not often noticed what appear to be pools of water on the roadway ahead with surrounding objects mirrored in them? Such have a similar explanation to those already described.

SPECTROSCOPIC ELEMENTS OF THE ECLIPSING VARIABLE GO CYGNI = H.D. 196628

By J. A. Pearce

THE variable nature of the 8th magnitude star GO Cygni = B.D. +34°.4095, was discovered photographically in 1928 by Schneller[1]. In the following year, the star was shown to be a short period eclipsing variable by Kukarkin[2]. In 1931 Syczyrbak[3] gave the light elements:

$$\text{Min} = \text{J.D. } 2426509.467 + 0.717767E,\ D = 3^h.6$$

and considered the star an Algol variable.

Recently Kukarkin[4] published a light curve from his observations at Taschkent, Turkestan, from 1929-1931. The curve is a typical β Lyrae curve with $\text{Max}_1 = \text{Max}_2 = 8^m.40$; $\text{Min}_1 = 8^m.83$ and $\text{Min}_2 = 8^m.51$. The elements for the principal minimum computed from all published observations are:

$$\text{Min} = \text{J.D. } 2426509.462 \pm 0.004 + 0.717767E \pm 0.000005$$

The Observations

TABLE I—OBSERVATIONS AND REPRESENTATIONS H.D. 196628

Obs.	Julian Date 2,420,000+	Final Phase	Vel I	(O-C)	Vel II	(O-C)	Lines
1	6953.673	0.631	+ 41	....	.....	...	3
2	6953.725	0.683	+ 19	....	.....	...	7
3	6953.788	0.028	− 24	+ 5	.....	...	5
4	6953.847	0.087	− 93	− 4	+116	+5	6-5
5	6953.903	0.143	−121	+ 2	+155	+3	4-3
6	6955.751	0.556	+132	− 3	−148	+3	6-6
7	6955.818	0.623	+ 58	....	.....	...	7
8	6957.787	0.438	+100	+12	−104	−8	2-2
9	6957.860	0.511	+130	− 3	−157	−9	5-5
10	6957.945	0.596	+123	+ 3	−134	0	5-5
11	6959.690	0.188	−128	+ 2	+151	−8	7-6
12	6959.777	0.275	− 88	− 2	+101	−7	6-5
13	6959.868	0.366	+ 9	− 3			9

1Schneller, A.N. 235, 85, 1928.
2Kukarkin, N.N.V.S. 2, 26, 1929.
3Syczyrbak, S.A.C. 10, 44, 1931.
4Kukarkin, N.N.V.S. 4, 19, 1932.

Thirteen spectroscopic observations were recently obtained on four nights. These were well distributed in phase and sufficient for the determination of the orbital elements. The camera employed was the short-focus camera *I*S, having a dispersion of 49A per mm. at $H\gamma$. An average exposure of $1^h\ 40^m$ on a Barnet emulsion was given, the mean photographic magnitude of the star being 8.6.

The Spectrum

Like most eclipsing variables of early type the spectral lines are nebulous and ill-defined. The lines of both components were measured on 8 plates whose relative velocities exceeded 190 km./sec. The lines chiefly used were: λλ 4861, 4481, 4471, 4341, 4101, 4026, 3933, usually the only lines available in Class B9n. An average of 5 double lines on the 8 plates and 6 single lines on the 5 plates was observed. One observation secured during secondary minimum, when the fainter star is eclipsed by the brighter showed a typical B9 spectrum. The helium lines 4471 and 4026 on this plate are relatively much stronger than their appearance on the other plates. The two observations taken during principal minimum show a number of faint metallic lines of class A0. The spectral types of the component stars are, therefore, considered to be B9n-A0n.

In addition to double stellar calcium *K* lines which were measured on 11 plates one spectrum showed a faint line due to interstellar calcium between the two oscillating *K* lines. The velocity of this interstellar *K* line was −13 km./sec.

The Solution

The observations assembled on the period of Kukarkin $P=0.717767$ days, showed no appreciable eccentricity. The preliminary elements, Table II, were adopted, and a least-squares solution effected for correction to the elements γ_1, K_1, K_2 and T. The epoch of principal minimum was adopted for T. The radial velocity is then

$$V=\gamma-K\sin\theta, \text{ where } \theta=\mu\,(t-T)$$

The differential equation of condition is thus:

$$dV=d\gamma-\sin\theta\,dK+K\mu\cos\theta\,dT$$

The primary velocities were weighted according to the quality of the plates and number of lines measured. The secondary

velocities were given 0.8 the weights of the primaries. The two blended velocities shown on the velocity diagram in phases 0.631 and 0.683 were omitted from the solution. Nineteen observational equations were formed from the eleven primary and eight secondary velocities.

TABLE II—SPECTROSCOPIC ELEMENTS

Element		Preliminary	Final
Period	P	0.717767	0.717767 days
Eccentricity	e	0.0 (assumed)	0.0
Longitude of Periastron	ω	indeterminate	.....
Periastron Passage	T	J.D. 2426953.042	6953.0425±0.0122
Velocity of System	γ	+3	3.2±1.04 km./sec.
Semi-amplitude of primary	K_1	130	133.2±1.74 km./sec.
Semi-amplitude of secondary	K_2	157	156.2±1.96 km./sec.

$a_1 \sin i = 1{,}314{,}600$ km.
$a_2 \sin i = 1{,}541{,}700$ km.
$M_1 \sin^3 i = 0.98 \odot$
$M_2 \sin^3 i = 0.83 \odot$
$M_2/M_1 = 0.85$

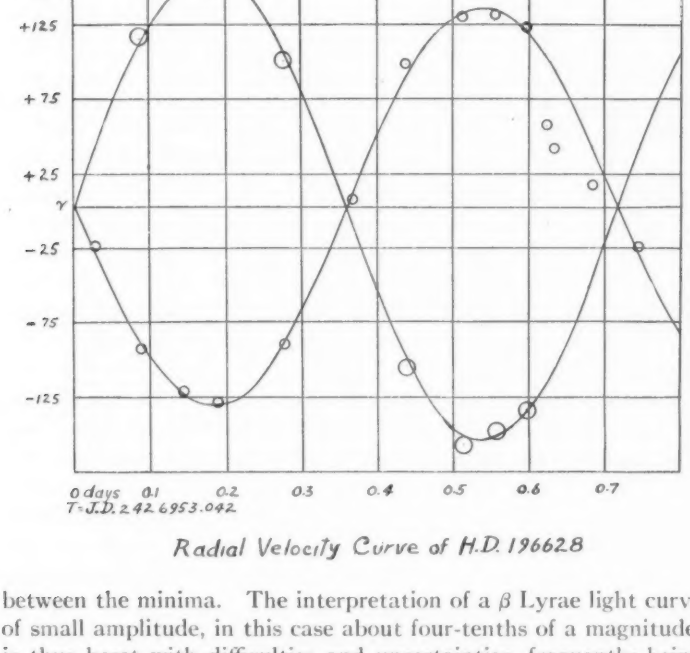
The final elements with their probable errors are given in table II. The least-squares solution resulted in an 8.5 per cent. reduction of $\Sigma\, pvv$. The probable errors of a single observation of weight unity are ±3.0 km./sec. for the primary and ±5.6km./sec. for the secondary.

The representation of the observations by the elements is shown on the velocity diagram, the radii of the plotted circles being equal to the probable errors of the component spectra.

The system is composed of two dwarf stars of spectral types B9 and A0 with masses similar to that of our sun. They revolve in sensibly circular orbits whose radii are approximately 1,000,000 miles, indeed not much greater than our sun's diameter. The period of rotation is $17^h\ 13^m\ 35^s.07$, which is also considered to be that of their axial rotation. It is well known that in such systems whose component stars are close together, their mutual attractions render the stars ellipsoidal in figure their largest axes being coincident with the line joining their centres.

Such revolving ellipsoids whose inner surfaces are seldom separated by distances exceeding their own diameters introduce

variations in light due to their ellipticity of figure and mutual reflections. These small variations must be computed and allowed for before the light elements due to the mutual eclipses of the binary system may be determined. The light changes of such an eclipsing system are continuous, with maximum light midway



Radial Velocity Curve of H.D. 196628

between the minima. The interpretation of a β Lyrae light curve of small amplitude, in this case about four-tenths of a magnitude, is thus beset with difficulties and uncertainties, frequently being indeterminate. The light curve of Kukarkin for GO Cygni, indicates the presence of small reflection and ellipticity effects. An effort will be made to interpret the curve, so that the absolute densities, masses and separations for these stars may be determined.

Dominion Astrophysical Observatory,
Victoria, B.C.,
September 24th, 1932.

THE ILLUSIONS OF MONS. ANTONIADI*

By H. Boyd Brydon

IN 1930 Mons. E. M. Antoniadi, "Astronomer attached to the Observatory of Meudon", published a monograph entitled "The Planet Mars, a study based on the results obtained with the great refractor of Meudon Observatory and analysis of all previous work on this planet since 1659". The study of Mars has occupied Mons. Antoniadi since 1888. His work at Meudon which this book summarizes was done, he tells us, between 1909 and 1916 and between 1924 and 1929.

Dr. Chant's brief notice (this JOURNAL, Vol. 24, p. 339) spoke in moderately high terms of the book and dangled before us a whole chapter entitled "The Illusion of the Canals." What could be more enticing! All the work of Schiaparelli, of Lowell and the Sliphers, of W. H. Pickering, Trumpler and a host of others, their observations, their many thousands of photographs showing the canals, their reports and considered comments—all one vast illusion! This book must be read.

Having read it and especially after studying chapter V, "The Illusion of the Canals", it is manifest that their reality rests unshaken. This latest attempt to disprove their existence fails completely.

In view of the remarkable nature of this contribution to areology it may be of interest to discuss some of Mons. Antoniadi's pronouncements and to examine briefly some of his evidence. One need not be a professional astronomer to do this any more than it is necessary to be a professional criminal to sit on the jury at a criminal trial.

The evidence being in, what weight should be allowed to the

*Note by the Editor.—The pages of this JOURNAL are open for discussion but not for controversy. Mr. Brydon opposes M. Antoniadi's interpretation of the markings on Mars as given in one chapter of his work on that planet. Space will be found for a suitable article supporting M. Antoniadi's views. It is to be hoped that following this discussion our readers may be led to examine M. Antoniadi's volume which is a valuable storehouse of information.

several statements? Putting aside Mons. Antoniadi's gross insults to these men who have devoted their lives to furthering our knowledge of the solar system and whose observational training and skill, whose common honesty and sincerity, are above question, let us follow our legal friends and enquire into the qualifications of the experts. The testimony of a witness in a particular matter must be judged by what is known of him in other matters. Unfortunately for Mons. Antoniadi, those he waves out of court have demonstrated their ability by successful work in other difficult scientific problems. They are thus tested witnesses while he himself appears to have done little else to entitle him to consideration. The value of his evidence therefore can be rated only by the conditions of his observations and by the statements in his book.

At once we meet the first of Mons. Antoniadi's illusions: He considers local seeing conditions of no importance.

"Nearly always at Meudon the best seeing has occurred during a period of light haze;" (We are after fine detail, remember, approaching the limit of vision even under the best conditions)—"for some twenty minutes after opening the dome the seeing is generally good, then it tends to deteriorate"—"there is a tendency for unsteadiness to increase as the night goes on"—"during the twenty years I have used the Meudon refractor, I have had few nights of perfect seeing—one night in fifty on the average" and he remembers in these twenty years but one really good night, "September twentieth, 1909," when the seeing "remained perfect for two hours". However, "as all terrestrial localities even Paris with its smoke and dust can sometimes give perfect seeing, the superiority of Flagstaff, for example, over Meudon only results in greater frequency of good seeing; transparency of the air being of no advantage".

Sir Isaac Newton thought otherwise:—"The Air through which we look upon the Stars is in a perpetual Tremour; as may be seen by the tremulous motion of shadows cast from high Towers and by the twinkling of the fix'd Stars—The only remedy is a most serene and quiet Air such as may perhaps be found on the tops of the highest Mountains above the grosser clouds".

As the brunt of Mons. Antoniadi's attack falls not unnaturally on the work done at Lowell Observatory, let us look at the seeing conditions there as compared with Meudon.

The Observatory of Physical Astronomy at Meudon, 532 feet above sea level, lies some 2½ miles South-west of Paris "with its smoke and dust". Its latitude is 48°.8 N. Now during the two periods 1909 to 1916 and 1924 to 1929 when Mons. Antoniadi was observing Mars at Meudon, its oppositions occurred during the winter months when Mars was south of the equator and consequently too near the horizon even at meridian for the seeing to be good, much less "perfect". Further, as W. H. Pickering remarks, (Report on Mars, No. 35, Pop. Ast. 1926) Meudon "lies in the great anti-cyclone belt of our planet. Within that belt seeing never is and never can be at all comparable with what is usually found in more southern localities". Under such conditions it is not surprising that fine detail is not seen at Meudon.

Lowell Observatory, at Lat. 35°.2 N., founded especially for planetary research and equipped with instruments designed for that purpose, is situated at an altitude of 7,250 feet in a tree covered oasis on a high mesa of the Arizona desert and has an auxiliary station on the San Francisco Peaks at an altitude of 11,000 feet.

What this means for such work may perhaps be realized from some remarks by G. W. Ritchey (this JOURNAL, Vol. 23, p. 28). At such sites "the conditions of atmospheric definition and transparency are at least as much superior to those at Mount Wilson as the latter are to the average conditions at the important observatories of Northern Europe and the north-eastern part of the United States—The overwhelming impressiveness, the incredible tranquility of the night sky seen at these very high semi-desert sites are beyond all description and imagination".

For Mons. Antoniadi, however, this means nothing. He is quite content with Meudon. For him Dawes' limit and Foucault's theoretical optics are the only criteria when observations of planetary detail are to be considered.

"Lowell", he says, "forgets that the best proof of the definition of an objective is the separation of close double stars". Mons.

Antoniadi here suffers from another illusion, that there is no difference in visibility between a line and a point, a very different matter from the separation of close doubles. He ignores the results of the many tests that Lowell and others made of the visibility of fine wires and W. H. Pickering's similar experiments (Report on Mars, No. 11), and because of his inability to see the canals at Meudon, which he defends by misapplying Dawes' limit and because two wood cuts in Flammarion's "Mars", made after two of Schiaparelli's many drawings, "do not conform rigorously to the laws of perspective", dismisses the work of Lowell, the Sliphers, Trumpler, W. H. Pickering and others as illusory and a mere pretense.

This imputation of false witness occurs several times in this monograph. Whatever Mons. Antoniadi may be in the habit of reporting as his "observations", these men do not pretend to see things. Their work has been repeatedly checked and their observations confirmed not only in this matter but in the observation of other difficult things, such, for instance, as fine detail in Saturn's ring system, confirmed by mathematical analysis. Mons. Antoniadi seems to have nothing to point to as proof of his ability as an observer except his failure to see things that others have seen. That he makes such a charge, however, is perhaps not surprising in view of the following restrained phraseology. He says: "It is necessary to add here that apart from the canals of the Italian astronomer (Schiaparelli) which have a basis of reality, there are the canals drawn by Lowell and his aides on Mars and the four other planets known to the ancients. The apparent canals on Venus, Jupiter and Saturn are dug in the clouds".

The unescapable inference from these sentences is that canals similar to those observed on Mars have been shown by Lowell and his aides on their drawings of Venus, Jupiter and Saturn. This is simply not true, as Mons. Antoniadi should know. No one will be deceived by this sort of nonsense, but one cannot avoid the conclusion that these words were not written inadvertently. That at least is no illusion.

To proceed with this tirade:—"Some authors have described Lowell's maps of Mars as 'cobwebs' and 'fly tracks', (terreurs des

mouches). The comparison is hardly unmerited. One can say the same for the canals of E. C. Slipher at Flagstaff. But what of Trumpler's non-existent close network of straight lines, proved false in the most categorical fashion by his own photographs and said to have been seen with the great Lick telescope; that telescope with which the illustrious Barnard was never able to distinguish any straight line on the planet. The canals of Slipher and Trumpler in defying perspective" (an assertion he does not atttempt to substantiate) "are proof evident and eternal that they have absolutely nothing to do with the configuration of the planet . . . The great refractor at Meudon has settled once and for all the question of the canals".

Strong language, my masters! Mons. Antoniadi's completely detached and scientific attitude is beautifully indicated by this use of the word éternelle.

Having killed the canals and their observers quite dead he seems afraid of their resuscitation, so falls back on what Lowell in "Mars and its Canals" aptly terms "the small boy theory".

"Because", says Lowell, "some boys of the Greenwich Charity School set to copy a canal expurgated picture of the planet, themselves supplied the lines which had been preceptorily left out, the Martian canals have been denied existence. . . . as to the instructions received, we are left in the dark. It looks as if some leading questions had unconsciously been put to them. At all events English Charity boys would seem to be particularly pliant to such imagination for when Flammarion re-tried the experiment with French school boys and even inserted spaced dots for the canals in the copy, not a boy of them drew an illusory line".

In his anxiety for the truth about the Martian canals one would expect Mons. Antoniadi to mention this test by Flammarion, but reference there is none. He worked for years in Flammarion's observatory and it is curious that it escaped his notice.

Mons. Antoniadi holds yet another illusion—that the unreality of the canals is demonstrated because Barnard and Hale were kind enough to congratulate him on the agreement of some of his 1909 drawings with certain of their photographs of that year. As he

does not reproduce the photographs nor designate the drawings we cannot check his statement. In those early days of planetary photography, however, such agreement was not unlikely especially as his drawings are free from all but major detail. But close as this agreement may have been in 1909, apparently his drawings even of such major detail were far from accurate in 1924. E. C. Slipher in "Observations of Mars in 1924 at the Lowell Observatory" (Pop. Ast., Vol. 32, p. 562) says:—"The continuous series of photographs obtained here during the last five months . . . show clearly that he (Mons. Antoniadi) has drawn the Southern (polar) cap many degrees (12° to 20°) larger than it is shown on the photographs, which of course tend to exaggerate its size due to imperfections of seeing and to irradiation".

He criticizes the Lowell observers for using reduced apertures to increase definition: "they have the pernicious habit of generally stopping down the 24 in. to 15 in. on the average which is equivalent optically to increasing the distance of Mars the better to see it, whereas the full aperture was used at Meudon, bringing the planet at least twice as near as at Flagstaff". Another illusion! Anyone with the slightest experience in photography knows that improved definition results from stopping down. His statement that the planet appears nearer by the use of a larger aperture is simply not true. Of course light grasp, vital in spectroscopy and in nebular photography, is substantially proportional to the area of the objective, but the size of the image, vital in planetary research, is proportional solely to focal length. Foucault's Optics should have taught him this.

Now at Meudon the focal length is 53 feet. At Lowell "the camera system is usually used at an equivalent focus of 180 feet. This means that the image on the plate is magnified about two hundred times. To put this in more familiar terms, the size of the photographic image of Mars . . . is from four to six times greater in surface than the moon seen with the naked eye". (E. C. Slipher, "Photographing the Planets, with especial reference to Mars." Pub. Ast. Soc. Pac., No. 193, 1921.)

This illusion of the value of aperture as distinct from focal length

in planetary research recurs throughout the book. As W. H. Pickering points out in his Report on Mars, No. 35: (Pop. Ast., 1926, p. 304) "The purpose for which very large telescopes are constructed at the present day . . . is distinctly not to obtain better definition of the moon and planets. For that purpose we now know that they are useless. The Yerkes telescope, those at Mount Wilson and the great reflector at Victoria, B.C., were built expressly to gather as much light as possible for the study of spectra and of faint stars and nebulae".

After admitting that "as an observer Schiaparelli was the master of us all", Mons. Antoniadi dismisses his canals "which have a basis of reality" as simply the result of eye-strain and says:—"Examination of my results in 1909 showed me a great variety of aspect and structure in these irregular bands. I found:—

(1) That about seventy per cent. of Schiaparelli's 'canals' are only irregular streaks of shade, more or less continuous or spotty, of various widths and appearance due to past convulsions of the skin of Mars.

(2) That about twenty-one per cent. of these 'canals' are only the ragged (déchiquetés) margins of greyish areas.

(3) That about nine per cent. are made up of single, isolated and complex lakes".

So much for Schiaparelli's canals, numbers of which have been confirmed many times on photographs.

Since the single canals are illusion, it were hardly worth while to discuss the doubles. But not for the earnest Mons. Antoniadi. Speaking of the many photographs on which doubled canals have been identified, he says: "The evidence for these doubled lines on the plates would only have value if nearly all the photographs taken successively on the same night showed them; such is not the case". He seems quite unable to grasp the difficulty of photographing such detail. E. C. Slipher's article referred to above gives some inkling of the problems involved. The eye sees an object instantaneously, while to photograph the delicate tracery of the canals on Mars "requires from 1½ to 2½ seconds. This relatively brief time of exposure no doubt seems of little importance, and it is if we were

concerned in photographing a still object or one subject to our control, but in the telescopic image we have neither of these. Aside from the minor difficulty of guiding the big telescope, air waves cause a blurring of the image because it is impossible to move the plate to allow for such rapid oscillations. Thus the resulting image is a poor average picture of the planet during the entire exposure time".

After indicating some of the mutually opposing factors that must be taken into account in making these photographs, Dr. Slipher proceeds as follows:—

"The photographs of Mars made at the Lowell Observatory furnish objective evidence of the following general statements concerning the planet:—

. . . the existence on the surface of the planet of a network of dark linear markings—the 'canals' and small dark spots—the 'oases'.

That these line-like markings are sensibly continuous and uniform throughout.

That the canals have individuality as between themselves, some being larger and more prominent than others.

That the canals run from one point to another with regularity and never stop short of a definite point of destination.

That many instances occur where two intersect and both continue to run precisely on their own straight course.

That some of the lines lie near together and parallel—the double canals.

That the separations of these differ.

Moreover, the majority of the canals that have been observed visually at the Lowell Observatory have been recorded repeatedly on the vast number of photographs made during the past fifteen years.

Finally, that the extensive visual observations made at the Observatory have been confirmed in toto and corroborated in detail by the photographs".

This factual summary was written in 1921. Ten years later Dr. Slipher remarks in a letter, "In connection with the whole Martian question I can assure you that as time goes on we continue

to amass additional evidence that our earlier views regarding conditions there are constantly being re-affirmed."

To Mons. Antoniadi, writing in 1930, this is all illusion and pretence.

To discuss in further detail his threadbare and discredited arguments would require a large volume. Suffice to say there is not in the whole work a single shred of evidence nor of argument for his absurd contention that has not been refuted years ago. He fails to see any dots, dashes, shadings or any other form of markings whatsoever where others see the canals and the photographs show them to exist.

If the surface contained spots or large dots such as he represents in his drawings and maps, photographs could not fail to catch them as such since they catch other things he has failed to see.

Further he has failed to catch numerous small sharply defined white spots about the melting polar snows and the many details within the melting snows such as the development of rifts, which are quite easy to see.

The only "Illusion of the Canals" is Mons. Antoniadi's own, that "the results obtained with the great refractor of Meudon Observatory" have proved them non-existent.

MIRA CETI, THE "WONDERFUL STAR"

By E. G. Hogg*

THE constellation of the Whale—Cetus—is not a conspicuous sky-group; no star in it attains even to the second magnitude. Within its boundaries, however, lies one of the most famous of all stars, Mira Ceti, the "Wonderful Star." This object is not given in Ptolemy's catalogue and the earliest notice of it is due to David Fabricius—one of the first observers of sun-spots—who records that a star of the third magnitude in Cetus, which he had seen in August, 1596, was not visible in the following October. This observation appeared at the time to be of great importance, as it seemed to show that some of the fixed stars might not be permanent —that they might shine for a period and then fade out. Seven years later Bayer found a fourth magnitude star in precisely the same position as the one whose disappearance Fabricius had noted. Here, however, the matter rested for a whole generation and it was not until 1638 that Holwarda detected the star again. He observed it reach a maximum in December, fade away during the following months, and reappear in the ensuing autumn. This star, which had been named Mira by Hevelius, was the first to become known as a long-period variable.

Mira has now been under observation for more than three centuries and, though the mystery that surrounds it has been, in part, dispelled, it still presents features which have not been adequately explained. In the first place its brightness at maximum varies between wide limits; sometimes it barely exceeds stars of the fifth magnitude in brilliance, sometimes it is distinctly brighter than the second magnitude, rivalling Aldebaran (1.1) in luminosity, but usually it ranks between the third and fourth magnitudes; at minimum brightness it generally falls to the ninth magnitude, but it has been known to reach the tenth. Mira, then, ranges through seven magnitudes in its brilliance, which means that the light

*In Astronomical Notes of the New Zealand Astronomical Society, for December, 1932.

reaching us at maximum is more than 600 times as intense as that received from it at minimum. Again the interval from one maximum to the next is not regular: the average is 331 days, but there are considerable fluctuations on either side of this period. It is this lack of uniformity in both maximum brightness and period, which constitutes the chief difficulty in apprehending the physical processes in operation here; it is not easy to reconcile the observations with either the supposition that Mira is a double star, its companion being small and very close to it, or with the hypothesis that it is a huge pulsating mass of gas similar to the Cepheid variable stars whose changes of luminosity appear to be most easily explained on this view.

Recent Work on Mira

In September, 1923, Professor A. H. Joy announced that, as the result of the study of 85 photographs of its spectrum when at minimum, Mira is a double-star, one member of which is a gaseous body of huge dimensions and low density. In the following month, Professor Aitken, of the Lick Observatory, confirmed this by reporting that he had detected the companion as a very minute star of a bluish colour half a magnitude fainter than the major body at minimum and situated over one second of arc from it. Further research has revealed that the variable member of the pair is a giant star whose diameter, as measured by the interferometer, is about 260 million miles, while the companion is a white dwarf similar to the one which revolves about Sirius. This binary system is about 660 light-years distant from the sun, from which it is receding at the rate of about 40 miles a second. Professors Joy and Aitken have now placed the problem of Mira on a secure basis, and it is only a question of time before the study of the accumulated observations will bring an explanation of the abnormal variations of brightness and period which have made Mira Ceti one of the most interesting stars in the heavens.

I am indebted to Mr. F. M. Bateson, Wellington, for the following information as to the recent doings of Mira:—"A maximum took place on April 12th, 1932, but there is a slight degree of uncertainty owing to the closeness of the star to the sun. At the present time Mira is at minimum, being magnitude 9.4. The pre-

dicted date of minimum was November 18th, but present indications are that it occurred about three weeks earlier." Nothing can then be seen of Mira with the naked eye at the present moment, but the observer can familiarize himself with the aspect of the constellation Cetus now and so be prepared to recognize Mira when it intrudes itself among the stars whose positions he knows as it moves up to the maximum which it should attain early in March next.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Correction to Note on the Reduction of Occultations

On page 40 of our last issue there appeared a brief article by Professors E. W. Brown and Dirk Brouwer on the reduction of occultations in 1933, and some corrections to it were received after it had been printed. The corrections are that certain quantities should be added, not subtracted. In line 2 for "subtracted from" substitute "added to"; in line 4, for "subtraction" substitute "addition"; and in line 7 for "subtracted" substitute "added".

Retirement of Sir Frank Dyson

Sir Frank Dyson, Astronomer Royal at Greenwich since 1910, and Astronomer Royal for Scotland from 1906 to 1910, having reached the age of retirement (65 years), will leave the public service on February 28, 1933. He will be succeeded by Dr. H. Spencer Jones, who was chief assistant at Greenwich from 1913 to 1923, and since then H.M. Astronomer at the Royal Observatory at the Cape of Good Hope. The best wish which the present writer can give to the new Astronomer Royal is that he may be a worthy successor to the long line of distinguished occupants of the position —and there is little fear that he will fail.

Fortieth Anniversary of "Popular Astronomy"

This well-known publication has completed forty volumes, and a comparison of the latest number with the first shows that it has pursued a very even path. This Journal wishes it a long continuation of its useful career.

Refraction? How?

In "Palestine as It Is", by M. J. Landa, referring to the Dead Sea, is the following: "We were in a vast trough of mingled desolation and beauty 1,300 feet below sea level. It was only eight o'clock in the morning, but the sun was beginning to blaze fiercely. With the intense refraction on the expanse of the sea, a purple haze was spread over the stern rocks of Transjordan on the opposite bank".

NOTE ON DECEMBER WEATHER—by Andrew Thomson.

Weather during December, 1932, departed considerably from normal in both Europe and America. Over Europe generally there was extremely little rain or snow, while both temperature and pressure were much above normal. In southeast Europe numerous stations reported the highest pressures that had occurred since their establishment. At Greenwich observatory during December the pressure was 0.17 in. and the temperature 2.2°F. above normal, while the rainfall was only 28% of normal, and these figures are typical of almost all European stations.

The part of America lying east of Hudson Bay, the Great Lakes and New Orleans, was considerably above normal temperature, while Western Canada and United States, except for the Mackenzie River Valley, was below normal. The usual path for the invasion of Arctic air into the American continent is up the Mackenzie Valley, with minor outbreaks over Baffin Land and Ungava. During December the paths of both warm and cold air masses were displaced, so that the main current of Arctic air swept down over the district of Keewatin and Manitoba, and on the western side of the Rockies. The result of this was that temperatures at Chesterfield Inlet and Churchill were 4° below normal, while Coppermine, which in recent years received the full force of outbreaks from the calotte of Arctic air, was 9°F. above normal.

Toronto, which has had nine consecutive winters above normal, started on the tenth winter with December 4°F. above normal.

ANOTHER PICTURE OF ONE HUNDRED YEARS AGO.

In the last number of the JOURNAL was a reference to the condition of France in 1832. There has come to the present writer's attention a description of conditions in England in 1830 which is worth quoting. It was written by Macaulay, who was reduced to such straits that he had to sell the gold medal which he had won at Cambridge.

> The present moment is one of great distress. But how small will that distress appear when we think over the history of the last forty years; a war, compared with which all others sink into insignificance; taxation, such as the most heavily taxed people of former times could not have conceived;

a debt larger than all the public debts that ever existed in the world added together; the food of the people studiously rendered dear; the currency imprudently debased, and imprudently restored. Yet is the country poorer than in 1790? We firmly believe that in spite of all the misgovernment of her rulers, she has been almost constantly becoming richer and richer. Now and then there has been a stoppage, now and then a short retrogression; but as to the general tendency there can be no doubt. *A single breaker may recede but the tide is evidently coming in.*

If we were to prophesy that in the year 1930 a population of fifty millions, better fed, clad, and lodged than the English of our time, will cover these islands—that machines constructed on principles yet undiscovered will be in every house—that our debt, vast as it seems to us, will appear trifling to our great-grand-children, many people would think us insane. We prophesy nothing; but this we say: If any person had told the Parliament which met after the crash of 1720 that in 1830 the wealth of England would surpass their wildest dreams—that stage-coaches would run from London to York in twenty-four hours, that men would be in the habit of sailing without wind, and would be beginning to ride without horses, our ancestors would have given as much credit to the prediction as they gave to Gulliver's Travels.

We cannot absolutely prove that those are in error who tell us that society has reached a turning point, that we have seen our best days. But so said all who came before us, and with just as much apparent reason.

C.A.C.

MEETINGS OF THE SOCIETY

AT HAMILTON

November 8, 1932.—The regular meeting was held in the Public Library lecture hall. Reports were given by members of the recent eclipse expedition and many slides were put on the screen showing the eclipse and the party in action.

The president, Mr. W. S. Mallory, paid tribute to the eclipse committee and regretted that Dr. D. B. Marsh was not able to attend the meeting. He gave a brief description of the eclipse and explained how eclipses occur.

Mr. T. H. Wingham gave an interesting and humorous talk on the trip down to Actonvale and the reception there by the Chamber of Commerce.

Dr. W. Findlay spoke for a few minutes on "How and Why" we study the sun. He pointed out that the sun is the most important part of our universe. We can get a great deal of information by using such instruments as the telescope, spectroscope and spectroheliograph, but that during an eclipse is the only time that the corona can be studied.

Mr. J. A. Marsh, past president, complimented Mr. Mallory on the success of the expedition.

The motion pictures of the eclipse taken by Mr. W. G. Milne were thrown on the screen and the meeting closed with the secretary giving a financial statement of the expedition.

December 13, 1932.—The regular monthly meeting was held in the lecture hall of the Public Library, at 8.15 p.m.

The president, Mr. W. S. Mallory, introduced the speaker of the evening, Mr. J. S. Taylor, of Richwood, Ont. Mr. Taylor gave an address on "The Motions of the Earth". He dealt particularly with Precession, Nutation, Changes in Eccentricity, and Obliquity of Earth's Orbit. The lecturer showed how it is that the earth's pole does not point to the same part of the heavens all the time. It swings in a path, completing its orbit in a period of about 26,000 years, which accounts for the fact that our present North Star has not aways been such. The lecture was interestingly illustrated with practical models.

On the motion of Mr. T. H. Wingham, the president conveyed the thanks of the meeting to Mr. Taylor.

The following were elected members:—Rev. E. Doe; Mr. Earlston Doe; Mrs. (Dr.) Marsh, and Mr. Victor Tillson.

Before closing, the president invited the members of the Society to send in suggestions regarding topics to be discussed at future meetings.

AT TORONTO

November15, 1932.—A regular meeting was held in the Physics Building of the University at 8 p.m.; Mr. R. A. Gray in the chair.

Three persons were elected to membership:—

Rev. R. E. O'Connor, 403 Wellington St. West, Toronto.
Mr. Murray D. Stewart, 282 Glencairn Avenue, Toronto.
Mr. John S. Allen, Dept. of Astronomy, Colgate University.

The constellation study, Cassiopeia, was conducted by Mr. J. Whitehouse, who gave an excellent description of this group.

Professor H. J. C. Ireton addressed the meeting on "The Spectroscope." Many branches of scientific research, such as astronomy, astrophysics, physics and chemistry are greatly indebted to this instrument for much of their progress. In astrophysics the spectroscope serves to deduce the chemical composition of a star by breaking up its radiation into its constituent wave-lengths no matter how distant the source, and the speed of a star in the line of sight. The solar prominences, which otherwise may be viewed only at a total eclipse of the sun, can be observed with this instrument.

The various parts include a narrow slit which is placed between the source of radiation and the prism, in order to give a slit-image, then a collimator lens by which the rays from the slit are made parallel. Next is the prism or grating, then the eyepiece or plate holder. The prism is the actual dispersing system in spectrum analysis, and as the merits of a spectroscope include high dispersive and large resolving powers, with a bright spectrum, the prism should be of good quality. For ultra-violet light, to which a glass prism is opaque, a grating is used, this is ruled with many thousand straight equi-distant grooved lines which reflect the rays, and give a much higher dispersion than a single prism. Several prisms may be employed to give a higher dispersion but the intensity is sacrificed owing to absorption in the glass and partial reflection at each surface.

The Doppler effect was described as of great importance in astrophysical work, since the amount of "shift" towards the red or violet ends of the spectrum denotes the velocity of recession or approach respectively of a heavenly body.

The wave lengths of Hertzian and the shorter electric waves are expressed in metres, light and X-rays in angstroms, the angstrom, indicated by the prefix Lambda, measuring approximately one ten-millionth of a millimetre.

The spectra of the known chemical elements are found to consist of bright lines or bands, each characteristic of the radiating atom or molecule, and designated by its wave-length in angstroms. Examples of various types of spectra were given, the line or discontinuous spectrum, caused by radiation from a glowing rarefied gas composed of atoms of elementary chemical substances and possessing a spectrum of bright lines crossing a dark background. The band spectrum, also composed of a glowing rarefied gas, but containing molecules of two or more atoms in combination, producing a discontinuous spectrum crossed by numerous bright lines, often so close as to form bands. The continuous or absorption class of spectra, where the source of radiation is an incandescent solid or liquid, or a dense gas, of which the sun is an example, contains a bright background of colour, from the red to the violet, crossed by numerous dark so-called Fraunhofer lines, which correspond in wave-length to the bright lines in the line and band spectra, the change in brightness being caused by the hot vapours

surrounding an incandescent body absorbing the waves they themselves would emit, thus scattering the energy, and resulting in loss of light.

The Chairman thanked Professor Ireton for his very instructive address, some interesting discussion followed and the meeting adjourned.

December 13, 1932.—A regular meeting was held at 8 p.m. Mr. A. R. Hassard in the chair.

There were four elections to membership:—Dr. Ludwig Silberstein, 129 Seneca Parkway, Rochester, N.Y.; W. A. Bobisud, Verdigre, Nebraska, U.S.A.; Andrew Thomson, M.A., Meteorological Service, Toronto; F. K. Dalton, 286 Willard Avenue, Toronto.

Mr. Andrew Thomson, M.A., of the Meteorological Service, gave an address on "Recent Developments in Weather Forecasting". Astronomers are able to forecast, years in advance, the occurrence of eclipses to a second, and the location of eclipse paths within a mile; on the other hand, meteorological forecasts of rain, temperatures and cloudiness are unfortunately of a very low order of precision for even two or three days in advance, and practically no progress has been made in forecasting weather for future months or seasons. Substantial improvement has been made, however, in recent years in short period forecasts for the next 12 to 36 hours, largely through the stimulus of the demands of aviation.

The Canadian Meteorological Service issues twice daily from its Toronto headquarters, forecasts for the vast region from the Rockies to the Grand Banks off Newfoundland. These forecasts are based on weather observations taken at approximately 8 a.m. and 8 p.m., E.S.T., at 225 stations scattered over Canada and United States, from Aklavik and Coppermine on the Arctic Ocean, south as far as Bermuda, Cuba and San Diego, Calif. Within recent years exceedingly useful stations, in sub-arctic Canada, have been established and equipped with radio which give timely warning of the outbreaks of polar air. To complete the chain and to fill the blanks in the uninhabited regions north of The Pas and in the centre of Ungava, would necessitate two or three more stations.

Messages sent by these stations include much more information than formerly, giving now such details as changes of barometric pressure in the previous three hours, approximate time of precipitation and whether light, moderate or heavy rain fall. Cloud forms and their direction and velocity, movements which are most useful indicators of the great currents of the upper atmosphere, have not as yet been included in the code messages from Canadian stations, and the addition of these data will probably constitute the next forward step.

Progress has been made in our knowledge of the physical conditions of the atmosphere associated with changes in weather, which have proved exceedingly helpful in forecasting. The trend has been away from the use of cyclone tracks, types of pressure maps and the use of barometric pressure data. Most forecasters now follow the movement over the region

in which they are interested, of large bodies of air with homogeneous properties called air masses. The idea of studying the trajectories of air particles and air masses was first advanced by Sir Napier Shaw and K. Lempfert in England, and was treated mathematically by the late F. M. Exner of Austria. Prof. V. Bjerknes and his son, J. Bjerknes of Norway, made the greatest practical advance when they showed on the daily weather map, that a cyclone or low pressure area was generally associated with the meeting of air masses with different temperatures, humidity and other properties. Bjerknes showed that when a cold air mass advances, it does so in the form of a wedge which pushes the warmer air up its inclined slope. The warm air is chilled about one Fah. degree for each 300 feet increase in elevation, so that at the resulting lower temperatures, its water vapour content may be transformed into rain. The rate of advance of the cold air mass can be deduced from the data supplied by the network of observing stations. Knowing the forward velocity, the time of rainfall at any specified place can be predicted often with considerable precision. In addition much other information concerned with temperature changes, form of cloud and transparency of the air may be had from the previous history of the advancing air mass.

One of the most hopeful investigations in Canadian meteorology is the study of the characteristic properties of the air masses which travel down from the Arctic Circle or which come northwards from the Gulf of Mexico, and which when passing over us in these temperate latitudes produce our sudden changes of weather.

The chairman thanked the lecturer for his most interesting address, and some discussion followed.

The officers of the Centre for 1932 were re-elected for 1933.

Dr. J. B. Fraser and A. R. Hassard were appointed as auditors. The reports of the secretary and the treasurer were read and adopted.

S. C. Brown, *Recorder.*

AT VANCOUVER

November 8, 1932.—The tenth regular meeting of the Vancouver Centre was held at the University of British Columbia. The president, Dr. Shrum, was in the chair.

The president announced that at least twenty-five members seemed to be willing to make the trip to Victoria for the purpose of visiting the observatories, and that the arrangements would be left to the incoming executive. Attention was directed to the fact that the next meeting would bring the election of officers for the coming year.

Mr. Teasdale then described the aspect of the sky for November, discussing the planets and constellations which are visible. He drew attention to the meteor showers of November 14 and 15, the Leonids.

The main speaker of the evening was Dr. J. G. Davidson of the Depart-

ment of Physics of the University, who presented an experimental lecture on "Light and Colour".

Starting with the question of reflection and colour, Dr. Davidson demonstrated that colour is determined by the part of the incident light which is reflected by the object. The principle of the spectroscope was then discussed, and the influence of the temperature of the source on the distribution of wave-lengths shown by projecting the spectrum from a lamp-filament whose temperature could be varied. The existence of radiant energy beyond the violet end of the spectrum, the ultra-violet, and within the red end, the infra-red, was demonstrated by means of a fluorescent screen and a radiometer. The transverse nature of light waves in contrast with the longitudinal vibration of sound was illustrated by mechanical contrivances.

The significance of wave-length was then discussed and colour compared with the pitch of a note. The limited range of the visible spectrum compared with the complete spectrum of radiant energy was emphasized. Colour, although associated with definite wave-lengths, was not an inherent characteristic of light, but really a physiological sensation produced in the human eye. Some interesting colour effects were produced by means of colour filters and the effect of these filters on the spectrum demonstrated. Samples of "daylight" glass and "make-up" glass were exhibited.

The lecturer closed with a demonstration of complementary colours and showed a few slides.

December 13, 1932.—The eleventh regular meeting and the annual meeting of the Vancouver Centre was held at the University of British Columbia. The president, Dr. Shrum, was in the chair.

Mr. Hawkins described the sky for December.

The Treasurer's Report was presented by Mr. Bennett, and showed a balance in the bank of $15.56. On motion the report was adopted.

The Secretary's Report was not available. On motion Dr. Ure was requested to draw up a report in accordance with the requirements of the parent body. (The list of officers for 1933 will appear in the March issue.)

Dr. Shrum, in retiring from the chair, spoke briefly on the work which had been accomplished, and expressed his hopes for the future progress of the Centre.

Mr. J. Teasdale, the new president, then took the chair, and expressed his appreciation of the honour which had been done him in his election to the position. After calling for a vote of thanks to the retiring executive, he emphasized the object of the Society, namely, to further the progress of astronomical and physical science at the present day, and made a plea for continued support on the part of the members.

The meeting continued with a symposium on the Solar System. In the absence of Mr. Pitman, who was to have spoken on the sun, Mr. Lighthall commenced the discussion with the earth. He described first the earth's movements and traced the historical development of knowledge with regard

to these. The early Greeks believed that the earth revolved about the sun, but the later epicyclic hypothesis made the earth the centre of all things. Copernicus (1473-1543) preached the more logical view, but Tycho Brahe (1546-1601) was a disciple of the old school. Rapid advance, however, came with the work of Galileo (1564-1642) who developed the use of the telescope, and the laws of Kepler (1571-1630) and Newton (1642-1727) placed the matter on a firm basis. The size and shape of the earth were then discussed. In spite of the measurement of the circumference of the earth by the Greek Eratosthenes, people continued to believe in a flat earth until the voyages of Columbus and Magellan. Later, MacLaurin demonstrated that the earth must be an oblate spheroid by measuring the differences in degrees of latitude near the equator and on approaching the poles. Such measurements are still being carried on over wide ranges of latitude. Discussing the origin and composition of the earth, the speaker contrasted the Nebular with the Planetesimal Theory and described the evidence for the belief that the earth has a metallic core.

The Inner Planets were described by Mr. Bennett, who first drew attention, by means of an analogy, to the extreme isolation of the solar system in space. The planet Mercury shows the same face to the sun at all times and is shown to have no atmosphere by measurements of quantity of reflected light. Venus is the one planet which shows the greatest similarity to the earth and apparently possesses an atmosphere.

Mr. Outram then discussed the Outer Planets, paying particular attention to the motions of the satellites of the various planets, and illustrating these motions by means of an ingenious mechanical contrivance. The outer two moons of Jupiter revolve in the opposite direction to that of the others. Uranus, with four moons, is situated with its poles in the plane of the ecliptic, which produces some interesting effects with reference to illumination of the planet by the sun, and also some peculiar apparent motions of the moons. Mars, with its two moons which are only 5 and 10 miles in diameter, must have some interesting moonlight effects, since the faster moon rises in the west and sets in the east and progresses from half to full moon in two hours.

With regard to our own moon, it is important to remember that the moon-earth system rotates about its centre of gravity, which is 1,000 miles below the surface of the earth. This fact accounts for the wavy motion of the earth in its orbit around the sun.

WILLIAM URE, *Recorder.*

AT WINNIPEG

November 18, 1932.—The regular monthly meeting of the Winnipeg Centre was held in Theatre A, University Building.

A short talk on "Meteoric Showers" was given by Dr. L. A. H. Warren, who stated that the most remarkable of these showers, the Leonids—so-called

because their lines of apparent motion radiate from the constellation Leo—occur between the 12th and 17th of November. He explained the cause of these showers and illustrated his remarks by means of lantern slides, which showed how the earth in its course around the sun came into contact with them. The display,—if clouds do not intervene—during the present month should be more brilliant than usual. Dr. Warren also drew attention to the fact that the ancients regarded meteors as objects of worship and referred to several classical writers in support of this statement.

The speaker of the evening, Professor Frank Allen, lecturing on "The Expanding Universe", said that in times long past there had been many conceptions of the universe and discussed some of the theories held by Ptolemy, Copernicus, Descartes, Newton, Einstein and de Sitter. All of these cosmologists regarded the universe as a static universe, that is to say, it could not disintegrate. In 1922, Friedman originated the idea of a non-static universe. In 1927, the Abbe Lemaitre, a Belgian mathematician, put forward views which were at variance with those advanced by the school of cosmologists prior to Friedman, and this view,—that the universe is not static and therefore not unstable—is accepted at the present time. Professor Allen laid emphasis on one point, namely, that in the consideration of the universe seven fundamental facts must necessarily be kept in mind: 1, Space; 2, Time; 3, Matter—which exists in two forms, diffuse and concentrated; 4, Motion; 5, Radiation; 6, Gravitation; 7, The redward shift.

All conceptions of the universe are ideal, strictly ideal, and the assumptions are such as can be submitted to mathematical treatment. We are trying to make some progress towards the solution of the real unknown universe. If the universe is expanding, some day it will be lost. Where will things go? When things get to the edge and more of the universe is gone into invisibility than is visible, will the fate of the universe be to vanish away quietly and unobtrusively?

The Psalmist says, "Of old hast thou laid the foundations of the earth, and the Heavens are the work of thy hands. They shall perish but Thou shalt endure. Yea, all of them shall wax old like a garment, as a vesture shalt Thou change them and they shall be changed." Professor Allen concluded by saying, "Modern science has caught up with the Psalmist."

The president, Dr. Neil John Maclean, conveyed the thanks of the Society to Professor Allen for his inspiring and instructive talk.

S. C. Norris, *Secretary.*

AT VICTORIA

December 15, 1932.—The Annual Meeting of Victoria Centre was held. Vice-President N. C. Stewart was in the chair.

After approval of minutes of last regular and annual meetings, the reports of the treasurer, secretary and librarian were adopted.

The scrutineers having presented their report on election of officers for

1933 they were declared elected. (The list of officers will appear in the next issue.)

After thanking the scrutineers for their report, the chairman called upon the new president, P. H. Hughes, who addressed the meeting on "The Cultural Value of Astronomy".

After a brief historical introduction, the speaker, in developing his subject under three heads, Justice, Eternity, Creator, said astronomy developed man's sense of justice and extended his conception of eternity and the Creator. Considered in the material way of length, width and height, compared with the infinite distances of the stars, man was but an ant. By linear measurement compared with the dimensions of the Galaxy, the score of Handel's "Messiah" was infinitesimal, but considered in other dimensions it was quite as important. The study of astronomy gave us a slight conception of these other dimensions, a glimmering of the endlessness and limitlessness of eternity and enlarged our idea of God's greatness.

Following the conclusion of the president's masterly and thought-provoking address, Dr. J. S. Plaskett expressed his appreciation and moved a vote of thanks to the retiring officers, speaking feelingly of the loss the Centre was sustaining by the absence from its councils of J. P. Hibben and Dr. J. A. Pearce. The vote was carried unanimously.

Mr. Charles Hartley drew attention to the remarks in the secretary's report regarding the financial circumstances of the Centre and proposed that the secretary be empowered to receive from the members voluntary contributions to aid in carrying on the work of the Centre and extending its activities. Seconded by Dr. J. S. Plaskett, the motion was carried unanimously.

The president then appointed a committee consisting of G. Browne-Cave, W. F. Holdridge, Dr. J. A. Pearce, with H. Boyd Brydon as chairman, to consider and report as to the formation of an Observer's Section in the Centre.

After the usual votes of thanks, the meeting then adjourned.

H. Boyd Brydon, *Secretary-Treasurer.*

The Royal Astronomical Society of Canada

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THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

The Astronomical and Physical Society of Toronto was incorporated in 1890, though it had existed some years before this; in 1900 it became The Toronto Astronomical Society; and on March 3, 1903, it was given permission to use the name, The Royal Astronomical Society of Canada.

Its objects are to study astronomy and cognate subjects, to publish the results of its work, and to maintain a library.

For many years the Toronto organization existed alone, but now the Society is national in extent, having active Centres in Montreal, P.Q.; Ottawa, Toronto, Hamilton and London, Ont.; Winnipeg, Man.; Victoria and Vancouver, B.C. Among its 800 members are a number of leading astronomers and scientists of the world, many amateurs, and, in addition, many laymen who are interested in the culture of the science.

The Society publishes a monthly JOURNAL containing each year about 500 pages of interesting articles and a yearly OBSERVER'S HANDBOOK of about 80 pages, containing valuable information for the amateur observer. Single copies of the JOURNAL or HANDBOOK are 25 cents.

Membership in the Society is open to anyone interested in astronomy. Annual dues, $2.00; life membership, $25.00 (no further dues). Publications are free to the members, or may be subscribed for separately.

Extract from the By-Laws: Candidates who are elected to membership will be attached to a particular Centre, or to a section known as *Members at Large*. Members of the Society who live outside of Canada, or in a province in which there is no Centre of the Society will be considered *Members at Large* and not attached to any particular Centre, unless these members are expressly nominated for membership and attachment to a particular Centre. Members may be transferred from one Centre to another, or to the section *Members at Large* by the Council of the Society if written application for such transfer is made by such member to the Council.

The library and offices of the Society are at 198 College St., Toronto, Ont. Applications for membership or for further information should be addressed to a local secretary (see back of this page) or to the General Secretary at the above address.